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Tuberculosis hospitalization expenditures per patient from private health insurance claims data, 2010–2014

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SUMMARY

OBJECTIVE—To determine hospitalization expenditures for tuberculosis (TB) disease among privately insured patients in the United States.

METHODS—We extracted TB hospital admissions data from the 2010–2014 MarketScan®commercial database using International Classification of Diseases version 9 codes for TB (011.0–018.96) as the principal diagnosis. We estimated adjusted average expenditures (in 2014 USD) using regression analyses controlling for patient and claim characteristics. We also estimated the total expenditure paid by enrollee and insurance, and extrapolated it to the entire US employer-based privately insured population.

RESULTS—We found 892 TB hospitalizations representing 825 unique enrollees over the 5-year period. The average hospitalization expenditure per person (including multiple hospitalizations) was US$33 085 (95%CI US$31 606– US$34 565). Expenditures for central nervous system TB (US$73 065, 95%CI US$59 572–US$86 558), bone and joint TB (US$56 842, 95%CI US$39 301–US$74 383), and miliary/disseminated TB (US$55 487, 95%CI US$46 101–US$64 873) were significantly higher than those for pulmonary TB (US$28 058, 95%CI US$26 632–US$29 484). The overall total expenditure for hospitalizations for TB disease over the period (2010–2014) was US$38.4 million; it was US$154 million when extrapolated to the entire employer-based privately insured population in the United States.

CONCLUSIONS—Hospitalization expenditures for some forms of extra-pulmonary TB were substantially higher than for pulmonary TB.

Keywords

TB; hospitalization; medical expenditures; in-patient claims; private insurance

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In the united states, active TB disease is typically successfully treated with 6 months of a combination of anti-tuberculosis drugs, often administered on an out-patient basis using directly observed therapy (DOT).[1,2] Although out-patient-based anti-tuberculosis treatment represents a shift from the sanatoria-based approach common before the 1960s,[3,4] one recent study of a cohort of TB patients reported that almost half (49%) of patients were hospitalized during TB diagnosis or treatment in the United States.[3,5]

Most (77%) TB prevention and control efforts (mainly diagnostic and treatment services) are provided by the public sector through local health departments; however, the introduction of the Affordable Care Act will likely increase the provision of TB health care services in the private sector.[6] As most of the direct costs of TB treatment come from hospitalization,[3,5] information on TB hospitalization can be useful for estimating resource use in TB prevention and control activities. Moreover, expenditure estimates for TB hospitalization among individuals with private insurance are important inputs when modeling the economic outcomes and burden on various payers of TB testing and prevention programs.

Although several studies have reported on TB hospitalization resource use, most of these are outdated (over two decades old[5,7,8]), presented data on hospital charges (not cost), described individual hospitalization episodes (excluded analysis of multiple TB hospitalizations per person), or reported estimates that excluded physician fees/charges.[1,4,9] In the present study, we estimated the average and total expenditures (paid by enrollee and insurance) for TB hospitalizations for persons with private insurance in the US by analyzing 2010–2014 in-patient claims data—a private sector perspective.

MATERIALS AND METHODS

For this study, in-patient claims data on private insurance claims for reimbursement from the Truven Health MarketScan® Commercial Claims Database (Truven Health Analytics, Ann Arbor, MI, USA) for 2010–2014 were analyzed. The 2010–2014 data contained claims information on at least 43 million people each year, which included employees, their spouses, and dependents (MarketScan). Based on the reported overall total employer-based privately insured population in the United States for 2010–2014, the annual enrollments provided in the database suggest that ≥25% of this population were represented in the database.[10–12]

Using the International Classification of Diseases version 9 (ICD-9) codes for TB (011.0–018.96), we identified and extracted in-patient admission claims information for all patients from the 2010–2014 in-patient records. Each record has a ‘principal diagnosis’ code (i.e., the main reason for in-patient stay[13]) and up to 14 secondary diagnosis codes. However, because our objective was to estimate expenditures that were likely attributable to hospitalization for TB disease, we restricted the extracted data to in-patient records having a principal diagnosis of TB disease, i.e., one of the TB ICD-9 codes specified above.

The MarketScan data contain fully adjudicated and paid insurance claims (total payments).[14] Each hospital admission record included information on total payments by both enrollee and private insurance plan.[13] Total payments also included both hospital and physician

payments.[13] Preliminary analyses indicated that some patients had more than one admission during the period covered (i.e., 2010–2014); because we wanted to estimate hospitalization expenditures per patient, we aggregated the associated payments and the duration of hospitalization (i.e., length of stay) for each patient.

Given the potential for the magnitude of the payments to differ substantially depending on the site of TB disease (i.e., extra-pulmonary TB [EPTB]), we controlled for (and estimated) the average expenditures for the different TB disease sites identified from the ICD-9 codes. Specifically, we used the following categories: pulmonary TB (PTB), other respiratory, central nervous system (CNS), intestinal, bone and joint, genitourinary/not elsewhere classified and miliary/disseminated. We totaled the expenditures for all the TB disease in-patient records that we identified and extrapolated these to estimate the total expenditures of TB hospitalizations for the entire US population with employer-based health insurance during the period of the analysis (2010–2014).

We used regression analyses to estimate the adjusted averages for all TB diseases, as well as for each EPTB category. As expenditures for 2010–2013 were adjusted to 2014 USD using the medical care component of the consumer price index,[15] all the reported expenditure estimates were in 2014 USD.

Regression analyses

Because all the expenditure data were positive, highly skewed and right-tailed, we used the generalized linear model (GLM) technique with log link and gamma distribution.[16,17] As in previously published studies,[1,17–19] we controlled for selected patient and claim characteristics based on the categories in the database[13] that included length of stay (days), age group (<15, 15–44 and ≥45 years), sex (male/female), number of admissions, admission type (surgical/medical), discharge status (dead/alive), drug benefit (whether or not enrollee's insurance plan included prescription drug coverage), region of the United States (South/Northeast/North/Central/West/unknown) and type of health plan (preferred provider organization [PPO]/comprehensive/exclusive provider organization/health maintenance organization/point of service [POS]/consumer driven health plan/high deductible health plan).[17–19]

To reduce the potential problem of high multi-collinearity, which can affect the magnitude and therefore the interpretation of the estimated coefficients of the control variables,[20] we checked the variance inflation factor (VIF < 10) and condition number (<15) based on Belsley et al.'s criteria.[21] Given the log-link specification, we transformed the coefficients from the regression analyses to interpret the results. For continuous control variables, we calculated the coefficient (β)*100 and interpreted them as the relative change (in percentage) per small change in the control variable. For categorical control variables, we calculated (e^{β} − 1)*100 and interpreted them as the relative difference (in percentage) in the estimated expenditures when compared to the referent category.[22]

The in-patient data were extracted using Data-Probe®, online version 5.2.11 (Truven Health Analytics Inc, Ann Arbor, MI, USA). The GLM estimation with log link and gamma distribution as well as the regression validation and diagnostics were executed in STATA,

version 14.0 (StataCorp LP, College Station, TX, USA). Microsoft Excel, version 2013 (Microsoft Corporation, Redmond, WA, USA) was used for presentation of summary results.

As all the data used in this study were from the MarketScan database, which contains retrospective data on de-identified enrollees (MarketScan), institutional review board approval was not required.

RESULTS

Table 1 shows the frequency of TB hospitalization by patient and claim characteristics. There were 892 TB hospitalizations representing 825 unique enrollees. Approximately 93% (n=769) of the patients had one TB hospitalization. Of the remaining 7% (n =56), 48 had two unique admissions, six had three admissions each, one had four admissions and another one had five unique admissions. For those with multiple admissions, we found that the largest gap in admissions (the difference between two successive admissions) for any patient was 481 days.

The average length of stay was 10 days (standard deviation 12, median 8, range 1–121). A slightly higher proportion of TB in-patients were aged ≥ 45 years compared with those aged 15–44 years (47% vs. 46%), while only 7% were pediatric in-patients (age <15 years). The majority (71%) of the admissions were coded as medical (vs. surgical). Based on discharge data, 2% of the patients (n =16) died and the remainder were discharged, transferred to another facility or left against medical advice (Table 1). Patients were slightly more likely to be male than female (56% vs. 44%). The region with the highest proportion of TB patients was the South (39%), followed by the West (23%). The North Central region had the lowest number of TB patients (15%). Approximately 2% of the patient location data were unknown or missing. A large majority of the TB admissions were for PTB (≈72%), while the other six TB disease site categories (EPTB diseases: other respiratory, CNS, intestinal, bone and joint, genitourinary/not elsewhere classified and miliary/disseminated) were fairly evenly distributed, ranging from 4% to 6%. We found 17–22% of total TB patients in each year we analyzed. The majority (75%) of the patients had drug benefits. Finally, the PPO was the dominant type of health plan, accounting for two thirds of the health plan types (Table 1).

Regression analyses

Table 2 shows the final regression results that were used to estimate the adjusted average expenditures for TB hospitalization for all TB disease sites taken together. Although, as expected, there were significant pair-wise correlations between some of the control variables, they were not high enough to cause multicollinearity problems, based on the criteria we used; the two highest correlation coefficients were: >1 admission vs. length of stay (ρ =0.45, P < 0.01) and >1 admission vs. CNS site of disease (0.20, P < 0.01). Our check for multicollinearity problems indicated that the VIF (mean 1.43, highest 4.57) and condition number (4.2) were all below the limits proposed by Belsley et al.[21]

The results indicate that an increase in the length of stay by 1 day increased average expenditure by 4% (P < 0.01). The expenditures for patients aged ≥ 45 years were 22%

higher than for those aged <15 years ($P < 0.01$). The expenditures for those with more than one in-patient admission were 36% higher than for those with one admission ($P < 0.01$). The expenditures for admission type coded as medical were 40% lower than those coded as surgical ($P < 0.01$). When compared to the expenditures from patients in the South, expenditures on patients from the Northeast and West were respectively 26% ($P < 0.01$) and 91% ($P < 0.01$) higher. The expenditures for CNS TB, bone and joint TB, and miliary/disseminated TB were higher than those for PTB, by respectively 106% ($P < 0.01$), 59% ($P < 0.01$) and 26% ($P < 0.05$). The expenditure for CNS TB was thus more than double that for PTB. The expenditures from the POS health plan type were 23% higher than those from the PPO plan ($P < 0.05$).

A summary of the estimated adjusted and unadjusted average expenditures for all hospital admissions for TB disease (and disease site categories) are presented in Table 3. We estimated that the average hospitalization expenditure for all TB admissions was US$33 085 (95% confidence interval [CI] US$31 606–US$34 565). Hospitalization expenditures for TB disease site categorized as CNS (US$73 065, 95%CI US$59 572–US$86 558), bone and joint (US$56 842, 95%CI US$39 301–US$74 383] and miliary/disseminated (US$55 487, 95%CI US$46 101–US$64 873) TB were significantly higher ($P < 0.05$) than for PTB (US $28 058, 95%CI US$26 632–US$29 484). The total expenditures for TB hospitalization were US$38.4 million over the 5-year period (2010–2014) of this analysis, and US$154 million when extrapolated to the entire employer-based private insurance population in the United States.

DISCUSSION

We analyzed 2010–2014 in-patient private insurance claims data to estimate expenditures for persons with private insurance associated with TB hospitalization. Based on our findings, there were 892 admission records representing 825 unique enrollees (≈7% had more than one TB hospitalization). The annual number of hospitalized TB patients we identified represents less than 2% of the cases reported in US surveillance data.[23] From hospital discharge data, we found that 2% (n =16) of hospitalized patients were known to have died. The estimated adjusted average hospitalization expenditures per hospitalized TB patient with private insurance were US$33 085 (in 2014 dollars). While the majority of TB hospitalizations were for PTB (≈72%), our analyses indicated that the estimated adjusted average hospitalization expenditures for some EPTB diseases (CNS, US$73 065; bone and joint, US$56 842; and disseminated, US$55 487) were significantly higher than for PTB. We estimated total expenditures for TB hospitalizations over the period (2010–2014) at US$38.4 million. Extrapolated to the entire US employer-based privately insured population, the total expenditures for TB hospitalizations over the period were estimated at US$154 million.

Our estimate of the average medical expenditures for TB disease hospitalization was substantially higher than the estimate (updated to 2014 dollars) reported by Holmquist et al.[4] (US$26 000) from the Healthcare Utilization Project, which includes public insurance payers. This was because Holmquist et al.[4] reported hospitalization costs, which do not include physician fees,[8,9] while the total in-patient payments provided in the MarketScan database included physician and hospital payments.[13] When we focused on hospital-only

payments, our estimate was similar, at US$27 000 (rounded to the nearest thousands). Our expenditures estimate was also similar to the hospitalization cost estimate of US$31 000 (updated to 2014 dollars) reported by Marks et al.[24] The 2% hospitalization fatality rate in MarketScan data was within the range reported by previous studies (2–12%),[1,25–27] although it was at the low end of the range.

Limitations

One major limitation of our study was that we could not differentiate multidrug-resistant (MDR) or extensively drug-resistant (XDR) TB from drug-susceptible TB. This was because we relied exclusively on ICD-9 codes to identify TB cases. Unfortunately, there are no codes specific to MDR-/XDR-TB. Furthermore, we did not have complete medical history data. However, MDR-/XDR-TB patients make up only about 1% of annual TB cases,[28] and their hospitalization costs, for those patients who survived, would have been at the high end of our estimates.[24] Our estimate does not include productivity or intangible costs (such as pain and suffering) incurred by the patients, nor does it include TB-related ancillary costs from out-patient visits or prescription drugs. Although we accounted for multiple admissions in our analyses, we could not determine whether subsequent visits were new cases (recurrent TB) or relapse cases.

As described above, we focused on the principal diagnosis for identifying TB disease as the main reason for hospital admission. However, the use of ICD-9 codes to identify TB disease has its limitations.[29,30] Our method of identification might have missed TB cases that were mistakenly recorded as a secondary diagnosis. As a result, we might have under/overestimated the number of TB cases that we identified in this study, although the degree and direction of the biases (in the number of cases and the associated cost estimates) is difficult to assess based on the available data. Additional data analyses, such as laboratory results and chart reviews, might help to improve the sensitivity and specificity of the identification process used in this study.[31]

The MarketScan database has some limitations. It contains information on selected employers/health plans that are largely based on the company's inclination to participate. It is therefore a convenience sample that does not include medium and small firms,[32] and might not be generalizable to the entire employer-based privately insured population in the United States. The rough estimate that we provided by extrapolating to the entire US employer-based privately insured population in 2010–2014 should therefore be interpreted with caution. For one or a combination of reasons, including clinician, data unavailability, or data entry errors, there may be some inaccurate/missing information.[33,34]

Strengths

Despite the limitations discussed above, this study has several strengths. First, the database is one of the largest private insurance databases in the United States. Reported data on the employer-based privately insured population in the United States suggest that the MarketScan database contained data on ≥25% of the employer-based privately insured population each year over the 5-year period covered in this study (2010–2014).[10–12] Second, the medical expenditures information provided in the database are total payments (not

charges), which included physician payments. Our estimates therefore represent actual full dollar amounts paid by the insurance companies and enrollees for the medical services provided for these in-patients in 2010–2014.[32,35] Furthermore, our study adds to the literature by providing previously unavailable estimates for the less common EPTB diseases, such as CNS, bone and joint, and miliary/disseminated TB. We did not find any study that explicitly estimated hospitalization costs/expenditures for EPTB diseases. Finally, our study provides relevant private insurance perspective information on TB hospitalization expenditures in the United States.

CONCLUSION

Using in-patient claims data for privately insured patients over a 5-year period (2010–2014), we estimated that the average hospitalization expenditure for in-patient stays with a principal TB diagnosis was US$33 085 in 2014. However, the average medical expenditures were significantly higher for some forms of EPTB than for PTB. In fact, although there were very few CNS TB disease patients compared to PTB patients, the estimated average expenditures for CNS TB were more than double those for PTB. When we extrapolated the results from our data to the entire US employer-based privately insured population, the overall total expenditures for TB hospitalization were US$154 million over the 5-year period (2010–2014). Given that a substantial proportion of the direct costs of anti-tuberculosis treatment comes from hospitalization,[3,5] and the introduction of the Affordable Care Act is expected to increase the provision of TB health care services in the private sector,[6] our estimates provide timely benchmarks. Additional studies are needed to provide TB hospitalization estimates for patients insured by public providers (Medicare, Medicaid, Veterans Health Administration, etc.) and for uninsured TB patients to be representative of the entire US population.

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Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the United States Centers for Disease Control and Prevention (CDC). Mention of company names or products does not imply endorsement by the CDC.

Conflicts of interest: none declared.

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Table 1

Patient and claim characteristics for in-patient admission records with a TB diagnosis code as the principal diagnosis (n = 825)

Variable	Frequency *n* (%)
Age group, years	
<15	56 (7)
15–44	390 (47)
≥45	379 (46)
Number of admissions	
1	769 (93)
>1	56 (7)
Admission type	
Surgical	241 (29)
Medical	584 (71)
Discharge status	
Alive (discharged/transferred/left)	809 (98)
Died	16 (2)
Sex	
Male	458 (56)
Female	367 (44)
Region *	
South	324 (39)
Northeast	171 (21)
North Central	123 (15)
West	192 (23)
Unknown	15 (2)
TB disease site categories (ICD-9 codes)	
Pulmonary (011.0–011.96)	593 (72)
Other respiratory (012.0–012.86)	35 (4)
Central nervous system (013.0–013.96)	49 (6)
Intestinal (014.0–014.86)	31 (4)
Bone and joint (015.0–015.96)	42 (5)
Genitourinary and not elsewhere classified (016.0–017.96)	31 (4)
Miliary/disseminated (018.0–018.96)	44 (5)
Year	
2010	179 (22)
2011	181 (22)
2012	179 (22)
2013	139 (17)
2014	147 (18)
Drug benefit	
No	203 (25)

Variable	Frequency *n* (%)
Yes	622 (75)
Type of health plan	
Comprehensive	10 (1)
Exclusive Provider Organization	3 (4)
Health Maintenance Organization	103 (13)
POS	49 (6)
Preferred Provider Organization	530 (67)
POS with capitation	4 (0)
Consumer Driven Health Plan	37 (5)
High Deductible Health Plan	23 (3)
Age, years, mean ± SD; median (range)	40 ± 17; 43 (1–64)
Length of stay, days, mean ± SD; median (range)	10 ± 12; 8 (1–121)

*South: Delaware, Maryland, District of Columbia, West Virginia, Virginia, Kentucky, North and South Carolina, Georgia, Tennessee, Florida, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma and Texas; Northeast: Maine, New Hampshire, Massachusetts, Vermont, Rhode Island, Connecticut, New York, New Jersey and Pennsylvania; North Central: Ohio, Michigan, Indiana, Illinois, Wisconsin, Minnesota, Iowa, Missouri, Kansas, Nebraska, South and North Dakota; West: Washington, Oregon, Montana, Idaho, Wyoming, Colorado, Utah, Nevada, California, Arizona, New Mexico, Hawaii and Alaska.[13]

TB =tuberculosis; ICD =International Classification of Disease; POS =point of service; SD = standard deviation.

Table 2

Regression analyses used to determine the adjusted medical expenditures for TB hospitalization *

Variable	β (95%CI)†	Transformed coefficient in % (95%CI)‡
Length of stay, days	0.0367 (0.0301 to 0.0433)	3.7 (3.0 to 4.3)
Age group, years		
<15	Reference	
15–44	0.0640 (−0.1281 to 0.2561)	
≥45	0.2020 (0.0082 to 0.3957)	22 (1 to 49)
Number of admissions		
1	Reference	
>1	0.3041 (0.0975 to 0.5107)	36 (10 to 67)
Admission type		
Surgical	Reference	
Medical	−0.5178 (−0.6239 to −0.4116)	−40 (−46 to −34)
Discharge status		
Alive (discharged/transferred)	Reference	
Died	0.2950 (−0.0948 to 0.6848)	
Sex		
Male	Reference	
Female	0.0276 (−0.0784 to 0.1336)	
Region§		
South	Reference	
Northeast	0.2289 (0.1064 to 0.3514)	26 (11 to 42)
North Central	0.0560 (−0.0881 to 0.2000)	
West	0.6486 (0.5275 to 0.7697)	91 (69 to 116)
Unknown	0.1452 (−0.1800 to 0.4705)	
Site of TB disease		
Pulmonary	Reference	
Other respiratory	0.0913 (−0.0658 to 0.2484)	
Central nervous system	0.7228 (0.5340 to 0.9116)¶	106 (71 to 149)
Intestinal	−0.1814 (−0.3998 to 0.0369)	
Bone and joint	0.4645 (0.1567 to 0.7724)¶	59 (17 to 116)
Genitourinary and not elsewhere classified	−0.0617 (−0.3461 to 0.2227)	
Miliary/disseminated	0.2344 (0.0474 to 0.4215)#	26 (5 to 52)
Year		
2010	Reference	
2011	0.0560 (−0.0702 to 0.1823)	
2012	−0.0331 (−0.1565 to 0.0903)	
2013	0.0934 (−0.0316 to 0.2183)	
2014	0.0289 (−0.0824 to 0.1402)	
Drug benefit		

Variable	β (95%CI)[†]	Transformed coefficient in % (95%CI)[‡]
No	Reference	
Yes	0.0736 (−0.0501 to 0.1972)	
Type of health plan		
Preferred Provider Organization	Reference	
Comprehensive	0.0959 (−0.5740 to 0.7657)	
Exclusive Provider Organization	−0.1036 (−0.3124 to 0.1052)	
Health Maintenance Organization	0.1036 (−0.0304 to 0.2377)	
POS	0.2081 (0.0084 to 0.4079)[#]	23 (1 to 50)
POS with capitation	−0.0238 (−0.7895 to 0.7419)	
Consumer Driven Health Plan	0.0295 (−0.1851 to 0.2442)	
High Deductible Health Plan	0.0342 (−0.1855 to 0.2538)	

[*] Dependent variable was the total payment for each patient.

[†] Derived from bootstrap-generated standard errors with 50 replications.

[‡] Only coefficients with significant *P* values (<0.05) were transformed for easier interpretation of main effects. Because of the log-link specification, the coefficients were transformed as coefficient (β)*100 and interpreted as the relative change (in percentage) per unit change in the independent variable for continuous independent variables, and as ($e^{\beta} - 1$)*100 and interpreted as the relative increase or decrease (in percentage) in the estimated medical expenditures when compared with the reference (or omitted) category.[22]

[§] See Table 1 for geographical distribution.

[¶] $P < 0.01$.

[#] $P < 0.05$.

TB = tuberculosis; CI = confidence interval; ICD = International Classification of Disease; POS = point of service.

Table 3

Estimated average medical expenditures of TB hospitalization by disease site category and overall from in-patient claims data, 2010–2014

TB disease site categories (ICD-9)	Unadjusted expenditures* Average ± standard deviation	Adjusted expenditures* Average (95%CI)
Pulmonary (011.0–011.96)	37 253 ± 57 541	28 058 (26 632–29 484)
Other respiratory (012.0–012.86)	43 327 ± 29 744	35 436 (29 470–41 401)
Central nervous system (013.0–013.96)	110 743 ± 139 705	73 065 (59 572–86 558)†
Intestinal (014.0–014.86)	39 746 ± 62 304	27 852 (23 058–32 646)
Bone and joint (015.0–015.96)	80 685 ± 79 157	56 842 (39 301–74 383)†
Genitourinary and not elsewhere classified (016.0–017.96)	35 575 ± 41 557	22 419 (16 657–28 182)
Miliary/disseminated (018.0–018.96)	83 766 ± 106 893	55 487 (46 101–64 873)†
All (011.0–018.96)	46 598 ± 71 497	33 085 (31 606–34 565)

*All expenditures are in 2014 US dollars.

†Significantly ($P < 0.05$) higher than the adjusted average expenditures for pulmonary TB disease.

TB = tuberculosis; CI = confidence interval; ICD = International Classification of Disease.